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SHORT REPORT

Effect of submergence and naproanilide application on the growth of hemp sesbania and rice

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INTRODUCTION

Hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. ex A. W. Hill] is an annual legume that grows to a height of 3 m. It is found throughout the southern USA and is considered to be one of the most common and troublesome weeds in two of 13 southern states (Webster 2000). Hemp sesbania caused the greatest reduction in rice (*Oryza sativa* L.) grain yields compared to several broad-leaved weeds tested in weed density experiments (Smith 1988).

Naproanilide [2-(2-naphthyloxy)propionanilide] is a selective herbicide that controls annual and perennial broad-leaved weeds in transplanted rice in Japan (Oyamada *et al*. 1986). There are only a few compounds available for the effective control of hemp sesbania in rice in the USA (Anonymous 1999), so we examined the herbicidal efficacy of naproanilide on this weed. This herbicide selectively controlled hemp sesbania after pre-emergence (PRE) and postemergence (POST) treatments in direct seeded rice under upland conditions (Hirase & Molin 2002). Rice is grown under flooded conditions, and management of irrigation offers an opportunity for weed control in rice fields. It has been demonstrated that many weeds can be controlled by flooding alone (Smith & Fox 1973). However, the efficacy of naproanilide on hemp sesbania has never been tested under submerged conditions.

The purpose of this study was to examine: (i) the effect of submergence on the growth of hemp sesbania and rice seedlings; and (ii) the effect of application timing and water depth on the herbicidal efficacy of naproanilide under submerged conditions.

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MATERIALS AND METHODS

Effect of water depth on growth

Twenty-five seeds of hemp sesbania or rice (cv. Lemont) were planted 0.5 cm deep in 4.5 cm of sandy loam soil (43% sand, 48% silt, 9% clay, 1.51% organic matter, pH 5.4) in plastic pots that were 15 cm in both diameter and depth. Plants were submerged PRE (1 day after planting) or POST (two-leaf growth stage for both species) with a water depth of 1, 5 and 10 cm in plastic containers in a greenhouse. Both plant species were also grown under upland conditions for comparison. The greenhouse temperature varied between 25 and 33°C, and natural light was supplemented by sodium vapor lamps to provide a 14 h photoperiod. Water depths were kept constant for 14 days with daily additions. At the end of the tests, plants were harvested by clipping at the soil surface, and the dry weight per pot was determined.

Effect of naproanilide on growth

Seeds of hemp sesbania and rice were planted as described and grown under upland conditions. When the effect of application timing was examined, plants were submerged in a water depth of 10 cm 1 day before the application of naproanilide. Water-dispersible granules of naproanilide (1.2 mm in diameter, Hirase & Kishi 1998) were applied directly to the water at POST-1 (hemp sesbania, cotyledon stage; rice, one-leaf stage), POST-2 (hemp sesbania, one-leaf stage; rice, 1.5-leaf stage) and POST-3 (two-leaf stage for both species). The naproanilide granules contained 30% naproanilide, 8% NK WG-2 (an anionic surfactant, Takemoto Oil and Fat Company, Aichi, Japan), 31% sodium hydrogencarbonate, and 31% tartaric acid. The rate of naproanilide applied was 3 kg ai ha^{-1} for all treatment times. When the effect of water depth was examined, naproanilide was applied at POST-2. Plants were submerged in water depths of 1, 5 and 10 cm 1 day before the application of 3 kg ai ha^{-1} herbicide granules. In all cases, plant dry weight was measured 14 days after application.

All experiments were conducted with three replications and repeated twice.

RESULTS AND DISCUSSION

Effect of water depth on the growth

The effect of submergence on the growth of both species in the absence of the herbicide was examined before the effect of naproanilide on hemp sesbania and rice. The recommended depth of flooding water is between 2.5 and 10 cm throughout the growing season in Mississippi Delta rice production areas (Anonymous 1999). Therefore, tests in this study were conducted with water depths between 1 and 10 cm. The growth of hemp sesbania was drastically reduced when the plants were submerged PRE (Table 1). Emergence of hemp sesbania was completely inhibited by 5 and 10 cm depths of water. When submerged PRE, the growth of rice was also suppressed by 47, 39 and 75% at 1, 5 and 10 cm depths, respectively. When submerged POST, leaves of hemp sesbania and rice grew above the water surface at depths of 1 or 5 cm, but most of the shoots of both species were under the water surface at a depth of 10 cm. The growth of hemp sesbania was reduced only slightly at depths of 1 and 5 cm and approximately 64% at 10 cm. When submerged POST, rice growth was slightly promoted at 1 and 5 cm water depths and reduced by 25% at 10 cm. Growth reduction by flooding may have been due to reduced oxygen levels or the accumulated toxic products of anaerobic decomposition (Smith & Fox 1973). Indeed, hemp sesbania germination was drastically reduced when oxygen concentration was decreased from 21 to 0% (Johnston *et al.* 1979). These results indicate that hemp sesbania can be controlled by PRE submergence, but not by POST submergence. Rice is more tolerant to submergence than hemp sesbania.

Effect of naproanilide on growth

Naproanilide decreased the dry weight of hemp sesbania seedlings by 65–95% with POST applications at 10 cm water depth (Table 2). The herbicidal efficacy of naproanilide was higher when the plants were treated at the cotyledon or one-leaf stage than at the two-leaf stage. Naproanilide had no effect on rice at any stage of application, therefore, it was considered that naproanilide selectively controlled hemp sesbania in rice under submerged conditions. Rice is reportedly tolerant to naproanilide (Oyamada *et al.* 1985). In this case, the selectivity between rice and a susceptible weed, *Sagittaria pygmaea* Miq., may be due to differential uptake of naproanilide or the conversion to NOP [2-(2-naphthyloxy)propionic acid], the active form of naproanilide. The herbicidal efficacy of POST-3 treatment on hemp sesbania was low (65% control) compared with that obtained at POST–1 (94% control), and at POST-2 (95% control). However, the dry weight of this plant

Table 1. Effect of water depth and submergence timing on the growth of hemp sesbania and rice

Submergence timing†	Water depth (cm)	Dry weight (% of plants in upland)‡		LSD (0.05)
		Hemp sesbania§	Rice§	
PRE	1	16.0	52.7	24.7
PRE	5	0	61.0	38.4
PRE	10	0	25.0	7.5
POST	1	92.7	129.3	14.1
POST	5	81.3	112.0	25.5
POST	10	36.0	74.7	22.7
LSD (0.05)		12.8	22.5	

† Plants were submerged at: PRE, 1 day after planting; POST, two-leaf growth stage. ‡ Dry weight was examined 14 days after submergence.
§ Dry weight of hemp sesbania in upland was: PRE, 0.35 g per pot; POST, 0.60 g per pot. Dry weight of rice in upland was: PRE, 0.40 g per pot; POST, 0.63 g per pot. LSD, least significant difference; POST, postemergence; PRE, pre-emergence.

Table 2. Effect of application timing on the herbicidal efficacy of naproanilide†

Application timing‡	Dry weight (% of control)§		LSD (0.05)
	Hemp sesbania¶	Rice¶	
POST-1	5.9	108.7	15.4
POST-2	5.4	106.8	22.0
POST-3	35.3	98.6	21.4
LSD (0.05)	11.0	29.3	

† Naproanilide (3 kg ai ha^{-1}) was applied on the flooded water maintained at 10 cm depth.
‡ Naproanilide applied POST-1 to hemp sesbania at the cotyledon and rice at 1-leaf growth stage, POST-2 to hemp sesbania at one-leaf growth stage and rice at 1.5-leaf growth stage, and POST-3 to hemp sesbania and rice at two-leaf growth stage. § Dry weight was examined 14 days after application. ¶ Dry weight of hemp sesbania control was: POST-1, 0.12 g per pot; POST-2, 0.17 g per pot; POST-3, 0.18 g per pot. Rice control dry weight was: POST-1, 0.32 g per pot; POST-2, 0.52 g per pot; POST-3, 0.57 g per pot. LSD, least significant difference; POST, postemergence.

Table 3. Effect of water depth on the herbicidal efficacy of naproanilide†

Water depth (cm)	Dry weight (% of control)‡		LSD (0.05)
	Hemp sesbania§	Rice§	
1	62.2	107.8	23.8
5	58.3	99.3	19.2
10	5.3	105.2	14.4
LSD (0.05)	18.6	14.1	

† Naproanilide (3 kg ai ha^{-1}) was applied on the flooded water at 1-leaf growth stage of hemp sesbania and at 1.5-leaf growth stage of rice. ‡ Dry weight was examined 14 days after application. § Dry weight of hemp sesbania control was: 1 cm, 0.51 g per pot; 5 cm, 0.52 g per pot; 10 cm, 0.29 g per pot. Rice control dry weight was: 1 cm, 0.41 g per pot; 5 cm, 0.44 g per pot; 10 cm, 0.35 g per pot. LSD, least significant difference.

without naproanilide was already reduced by 64% under submerged conditions (Table 1; 10 cm, POST). Thus, the dry weight of this weed was decreased by almost 90% compared with untreated plants in non-flooded conditions. Overall, hemp sesbania was effectively controlled by the combination of submergence and naproanilide treatment. The naproanilide efficacy was higher when the application timing was earlier.

Naproanilide treatments reduced the dry weight of hemp sesbania by 38, 42 and 95% in 1, 5 and 10 cm water depths, respectively (Table 3). This result suggests that water depth is an important factor in the herbicidal efficacy of naproanilide. Herbicidal efficacy of this compound against *S. pygmaea* was also higher at 6 cm water depth than at 2 cm (Hirase *et al*. 1994). Naproanilide is absorbed through the leaf surface (Oyamada *et al*. 1986), therefore, greater amounts of naproanilide might have been absorbed by hemp sesbania in deeper water due to the greater percentage of plant surface area in contact with the water.

In conclusion, naproanilide treatment with submergence resulted in effective control of hemp sesbania. The efficacy was higher at earlier application timing or under deeper water conditions.

REFERENCES

Anonymous. 1999. Rice production. In: *Delta Agricultural Digest*. Intertec Publishing, Clarksdale, 149–176.

Hirase K. and Kishi D. 1998. Diffusion of naproanilide in water from high release granules and their herbicidal efficacy. *J. Weed Sci. Technol.* **43**, 49–53.

Hirase K. and Molin W.T. 2002. Effects of naproanilide and 2-(2-naphthyloxy)propionic acid on germination and seedling growth of hemp sesbania and rice. *Weed Sci.*, in press.

Hirase K., Shimono S. and Asano T. 1994. Diffusion of naproanilide in water from bubbling tablets and formation of its metabolite NOP. *Weed Res. Japan* **39**, 249–255.

Johnston S.K., Walker R.H. and Murray D.S. 1979. Germination and emergence of hemp sesbania (*Sesbania exaltata*). *Weed Sci.* **27**, 290–293.

Oyamada M., Tanaka T., Takasawa Y. and Takematsu T. 1985. Selectivity and absorption of the herbicide naproanilide in rice plants (*Oryza sativa* L.) and *Sagittaria pygmaea* Miq. *J. Pesticide Sci.* **10**, 469–474.

Oyamada M., Tanaka T., Takasawa Y. and Takematsu T. 1986. Absorption of naproanilide by several plants and effects of other herbicides on its absorption. *Weed. Res. Japan* **31**, 124–129.

Smith Jr. R.J. 1988. Weed thresholds in southern U.S. rice, *Oryza sativa*. *Weed. Technol.* **2**, 232–241.

Smith Jr. R.J. and Fox W.T. 1973. Soil water and growth of rice and weeds. *Weed Sci.* **21**, 61–63.

Webster T.M. 2000. Weed survey – southern states. *Proc. South. Weed Sci. Soc.* **53**, 247–274.